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(54) Abstract Title
Apparatus for circulating fluid

(57) The apparatus 1 for circulating fluid in a borehole has two outlets 6, 13. One outlet 13 is closed by a sleeve 9 in one stage of use, and opened in a second stage of use by rotating the sleeve 9 relative to the remainder of the apparatus 1. The relative rotation is enabled by the co-operation of the sleeve 9 with a formation in the borehole.

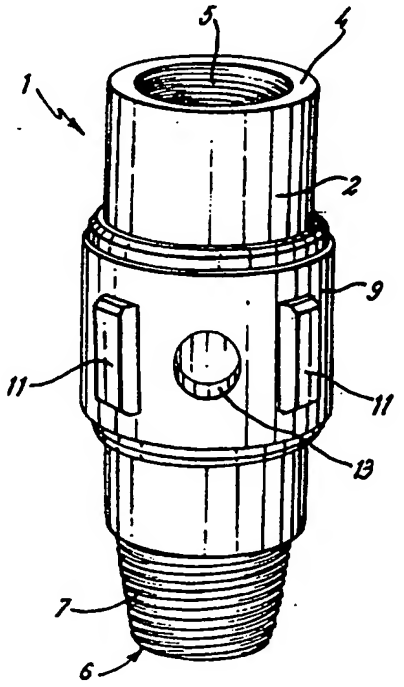

FIG.2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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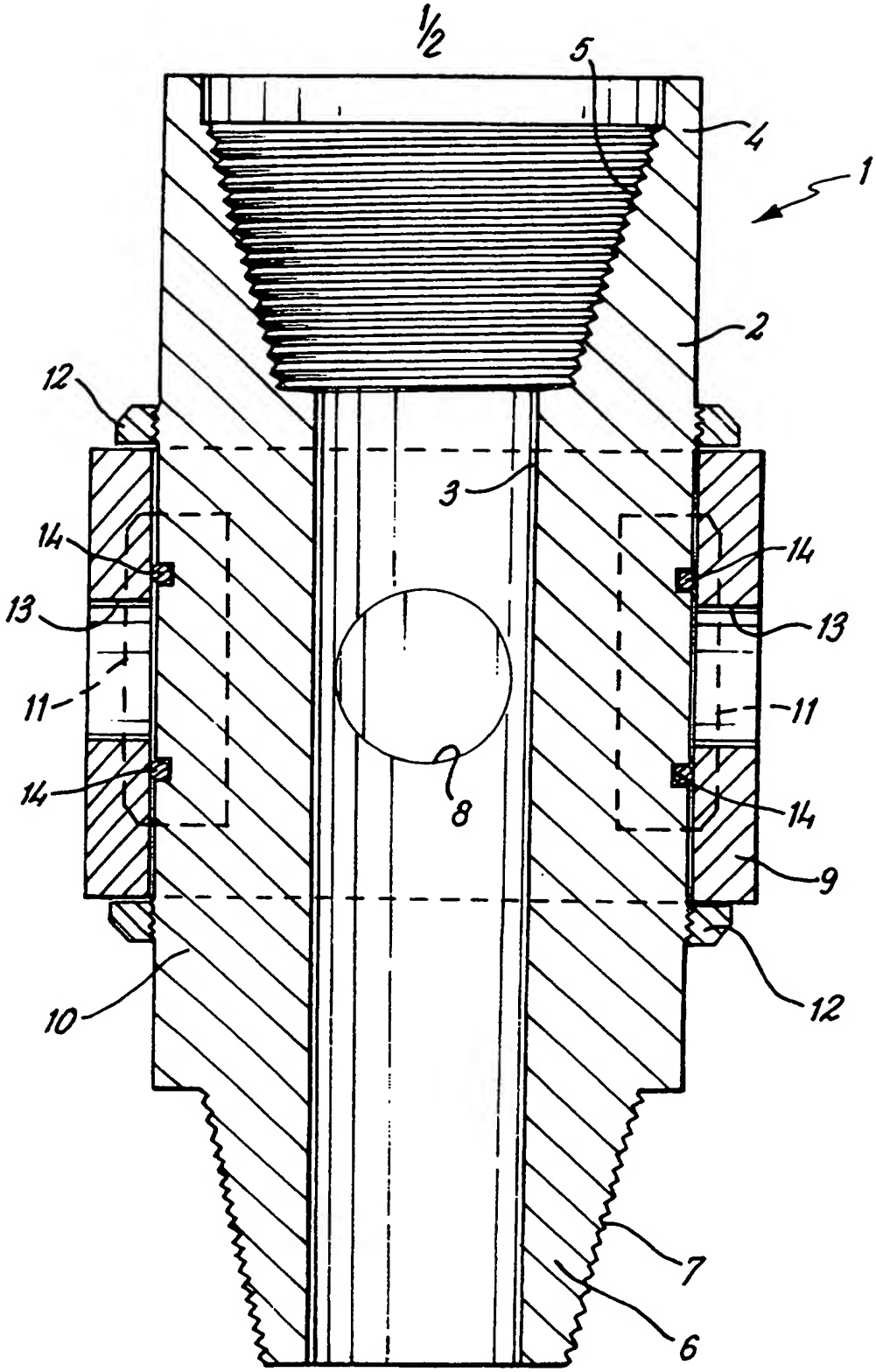

FIG. 1

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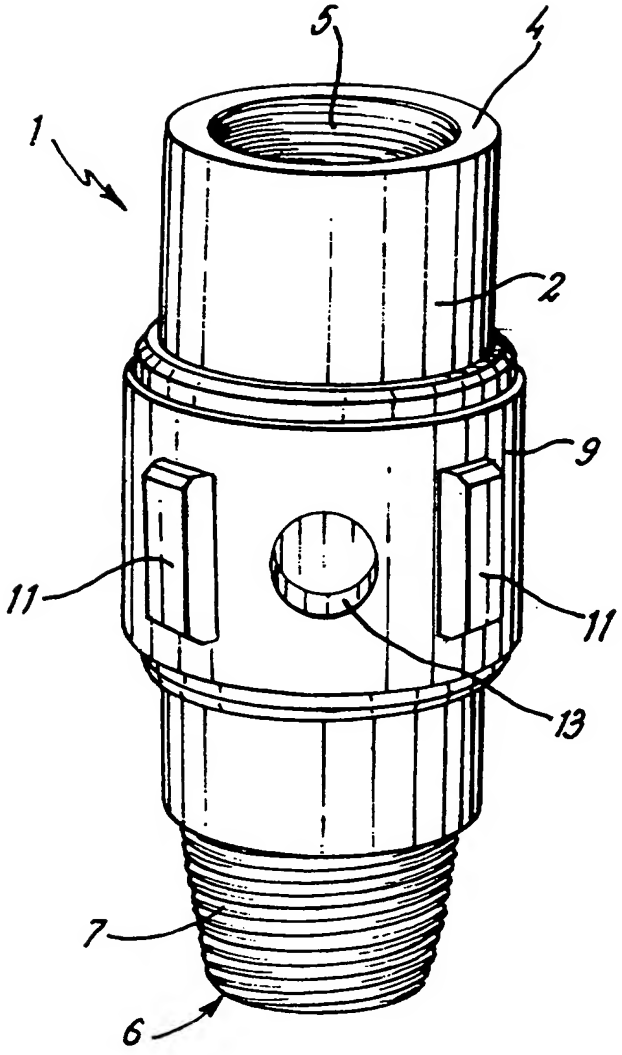

FIG.2

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APPARATUS FOR CIRCULATING FLUID

The invention relates to apparatus for circulating fluid and in particular, apparatus for circulating fluid in a borehole, and to a method of cleaning a borehole using the apparatus.

It is common practice to install liners within a borehole which has been drilled and after installation of the liners it is generally necessary to clean out the inside of the liner to wash away any debris or other contaminants.

Generally, the liner is in the form of a cylindrical tube which has a relatively small internal diameter compared with the diameter of casing lining the borehole immediately above the liner. To effectively clean out inside the liner, high flow rates are generally required to create turbulence to aid the cleaning out process. Generally, the clean out procedure is carried out by first passing cleaning liquid through the drill string to the lower end of the liner at a high flow rate so that the cleaning fluid flows turbulently up the annulus

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between the inside of the liner and the outside of the drill-pipe and then into the casing above the liner.

However, because of the difference in volume between the liner and the casing above the liner, after the cleaning fluid passes the top of the liner and enters the relatively large volume of the casing, the flow rate of the cleaning fluid in the casing above the liner is greatly reduced and any cleaning action becomes negligible.

Hence, it is generally necessary after passing cleaning fluid through the liner to then pass further cleaning fluid from the drill-pipe into the casing at a location above or adjacent the top edge of the liner, so that a high flow rate and hence turbulence of the cleaning fluid can be obtained in the casing. Therefore, it is generally necessary to have some device at or adjacent to the top end of the liner which can be operated downhole to either circulate fluid through the length of the drill string to the lower end of the liner or which can direct cleaning fluid at high flow rates out of the drill string into the casing above the liner, at or adjacent the top edge of the liner.

Once such device that is known for carrying out this operation comprises a hollow body member and in order to change the direction of flow between the bottom of the liner and the top edge of the liner, spherical balls are dropped down the drill string to open or close valves in the device.

However, there are a number of disadvantages associated with this apparatus. In particular, the length of time

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associated with the spherical balls falling from the surface to the device through a drill string which is perhaps a few thousand feet in length can take 25 to 30 minutes. Hence, there is problem with co-ordinating the arrival of the spherical ball at the apparatus to coincide with the arrival of the required cleaning fluid at the apparatus. It is also necessary to ensure that the increasing and decreasing flow rates associated with the liner and the casing clean out are co-ordinated with the arrival of the spherical ball at the apparatus.

In addition, it is generally necessary to repeat the cleaning out of the liner and the casing a number of times with different cleaning fluids until a situation is obtained in which the last clean out is carried out with sea water. Hence, it is necessary to be able to repeatedly operate the apparatus to divert flow between the lower end and upper end of the liner a number of times. With the apparatus described above there is the disadvantage that the apparatus is designed so that each spherical ball that is dropped down the drill string changes the direction of clean-out liquid flow either from the lower end of the liner to the upper end or from the upper end of the liner to the lower end of the liner. Hence, the number of times which this apparatus can be used to cycle fluid between the lower and upper ends of the liner is limited by the design of the device and when the spherical balls have been used or the tool is full with spherical balls and cannot be cyclically operated further, it is necessary to extract the drill string from the borehole in order to recover the device and remove the spherical balls from the device.

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In addition, there is also the danger that the spherical balls may not properly engage with the device and the risk that the device will not operate correctly.

In accordance with the present invention, there is provided apparatus for circulating fluid in a borehole, the apparatus comprising a tubular assembly comprising a body member having an axial through passage between an inlet and a first outlet, the inlet and the first outlet being adapted for connection in a work string supported from the surface, a second outlet extending generally transversely of the assembly; and a sleeve rotatably mounted on the body member for rotation between a first position closing the second outlet and a second position permitting fluid flow through the second outlet; and in which the sleeve is engageable with a formation in the borehole such that when the sleeve is engaged with the formation, the sleeve is rotationally stationary with respect to the borehole and the tubular body member may be rotated with respect to the sleeve to move the sleeve between the closed and the open position.

As used herein, the term "work string" refers to a number of lengths of drill pipe threadedly coupled together to form the work string, which may also be referred to as the "drill string".

Typically, the formation may be part of the equipment installed in the well bore as part of the well casing, and may include casing cross-overs and the liner equipment, such as polished bore receptacles (PBRs), profile subs, liner hangers, liner top packers or a setting sleeve. The formation may be provided by a recess or a protrusion on the inner surface of the

equipment, or by a reduction in internal diameter, for example the top edge of a liner within the borehole.

Preferably, said formation in the borehole is defined by a vertical recess in the borehole and the sleeve includes a radially extending projection which is engageable with the recess. Most preferably, said formation is provided by at least one vertical recess at or adjacent to the top of a PBR, such as at the top of a liner.

Typically, the sleeve may be biased into said first position by a biasing mechanism such as a spring.

Preferably, the second outlet comprises a number of apertures in the body which communicate with the inlet and typically, the apertures may be distributed circumferentially around the outer surface of the body member.

Preferably, the sleeve has a number of apertures therein which communicate with the second outlet when the sleeve is in the second position. Typically, when the sleeve is in the first position, the sleeve obturates the second outlet.

The apertures in the sleeve may be designed to direct the fluid exiting the second outlet in an upwards, downwards or radial direction into the casing.

From another aspect, the invention provides a method of cleaning a borehole which has a lower section defined by a liner and an upper section; the method comprising inserting into the borehole a work string which includes the apparatus according to the first aspect, until the

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work string extends into the lower section of the borehole; passing a desired cleaning fluid down the work string to the inlet of the apparatus and thence via the first outlet to the interior of the liner; subsequently engaging the sleeve with the formation in the borehole to maintain the sleeve rotationally stationary with respect to the borehole and rotating the work string relative to the sleeve and the borehole to open the second outlet; and passing the cleaning fluid down the work string to the inlet of the apparatus and thence via the second outlet to the interior of the borehole above or adjacent the top of the liner.

An example of apparatus for circulating fluid in a borehole in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Fig 1 is a cross-sectional view through a circulating tool; and,

Fig 2 is a perspective view of the apparatus shown in Fig 1.

Figs 1 and 2 show a circulation tool 1 which comprises a body member 2 which has a throughbore 3 with a diameter of approximately 50mm (2.0"). End 4 of the body member 2 has a male threaded coupling 7. In a central section 10 of the body member 2 are located two circumferentially distributed holes 8 (only one shown).

Rotationally mounted on the outside surface of the body member 2 is a sleeve 9. Located in the sleeve 9 are two circulating ports 13. Also mounted on the body member 2

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to engage the sleeve 9 are two O-ring seals 14 which sealingly engage with the sleeve 9.

Threadedly coupled to the body member 2, on either side of the sleeve 9, are two lock rings 12. The lock rings 12 maintain the sleeve 9 in position on the body member 2 while permitting the sleeve 9 and body member 2 to rotate with respect to each other.

The sleeve 9 has four dogs 11 (only two shown). The dogs 11 may be spring biased to the position shown in Fig 1 and so that they may be pushed into the sleeve 9 to be flush with the outside surface of the sleeve 9. Alternatively, the dogs 11 may be fixed to the sleeve 9, as shown in Figs 1 and 2.

In operation, the tool 1 is connected via the male connector 7 to the upper end of a lower portion of a work string and an upper portion of a work string is connected to the upper end 4 of the tool 1 using the female connector 5 to form the completed work string. The work string and tool 1 are lowered into a borehole until the tool 1 enters the upper end of a liner in the borehole.

In this position, the holes 8 in the body member 2 are obturated by the sleeve 9 and fluid can be pumped through the bore 3 in the tool 1 via the work string to exit the tool 1 through the end 6 into the work string below. Hence, fluid is pumped down the work string to the lower end of the liner to clean out the liner below the tool 1.

After the liner has been cleaned out, the work string is manipulated so that the dogs 11 engage a shoulder, recess or other formation in the borehole which rotationally

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locks the sleeve 9 with respect to the borehole. Typically, the formation may be provided by vertical recesses located in the liner adjacent to or at the PBR at the top end of the liner. The work string and body member 2 may then be rotated with respect to the sleeve 9 and the borehole to align the ports 13 in the sleeve with the holes 8.

When the sleeve 9 is in this second open position, fluid is free to pass from the throughbore 3 of the body member 2 and out through the holes 8 and circulating ports 13 into the casing or adjacent the top end of the liner, to washout the casing above the liner.

It is possible to determine when the ports 13 and holes 8 are aligned as this will produce a pressure drop in the work string which will be visible via instrumentation at the surface of the borehole.

In order to start circulating fluid to the bottom of the liner again, the holes 8 can be obturated by further rotation of the work string relative to the sleeve 9 and the borehole to obturate the holes 8 with the sleeve 9. Fluid can then be circulated through the work string to the lower end of the liner for cleaning out the liner again.

Hence, the invention has the advantages of permitting circulation of fluids to separate regions in a borehole by rotation of the work string relative to the borehole. Hence, the tool has the advantage of operating without any effective time delay and also have the advantage that it facilitates circulation of the fluid between the two

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regions without any limitation on the number of times recirculation can be achieved.

A liner may also be run on the work string with a liner running tool included in the work string. The circulation tool 1 may then be used to displace and clean by means of circulation, mud and cement from the well bore to perform the clean-up. Circulation can take place either down the work string or down the annulus between the casing and the work string.

Further modifications and improvements may be incorporated without departing from the scope of the invention herein intended.

CLAIMS

1. Apparatus for circulating fluid in a borehole, the apparatus comprising a tubular assembly comprising a body member having an axial through passage between an inlet and a first outlet, the inlet and the first outlet being adapted for connection in a work string supported from the surface, a second outlet extending generally transversely of the assembly; and a sleeve rotatably mounted on the body member for rotation between a first position closing the second outlet and a second position permitting fluid flow through the second outlet; and in which the sleeve is engageable with a formation in the borehole such that when the sleeve is engaged with the formation, the sleeve is rotationally stationary with respect to the borehole and the tubular body member may be rotated with respect to the sleeve to move the sleeve between the closed and the open position.

2. Apparatus as claimed in Claim 1 wherein the formation is part of equipment installed in the well bore in association with the well casing.

3. Apparatus as claimed in Claim 1 or Claim 2 wherein the formation is provided by a recess or a protrusion on the inner surface of the equipment.

4. Apparatus as claimed in Claim 1 or Claim 2 wherein the formation is provided by a reduction in internal diameter of well tubing in the borehole.

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5. Apparatus as claimed in any one of Claims 1 to 3 wherein the formation is provided by the top edge of a liner within the borehole.

6. Apparatus as claimed in any one of Claims 1 to 3 wherein said formation in the borehole is defined by a vertical recess in the borehole and the sleeve includes a radially extending projection which is engageable with the recess.

7. Apparatus as claimed in Claim 6 wherein said formation is provided by at least one vertical recess at or adjacent to the top of a PBR, such as at the top of a liner.

8. Apparatus as claimed in any one of the preceding Claims wherein the sleeve is biased into said first position by a biasing mechanism such as a spring.

9. Apparatus as claimed in any one of the preceding Claims wherein the second outlet comprises a number of apertures in the body which communicate with the inlet.

10. Apparatus as claimed in any one of the preceding Claims wherein the sleeve has a number of apertures therein which communicate with the second outlet when the sleeve is in the second position and when the sleeve is in the first position, the sleeve obturates the second outlet.

11. Apparatus as claimed in Claim 10 wherein the apertures in the sleeve are designed to direct the

fluid exiting the second outlet in an upwards, downwards or radial direction into the casing.

12. A method of cleaning a borehole which has a lower section defined by a liner and an upper section; the method comprising inserting into the borehole a work string which includes circulating apparatus until the work string extends into the lower section of the borehole, wherein the circulating apparatus has an inlet, a first and second outlet and an obturating member for obturating the second outlet; passing a desired cleaning fluid down the work string to the inlet of the apparatus and thence via the first outlet to the interior of the liner; subsequently engaging a part of the apparatus with the obturating member with a formation in the borehole to maintain the part rotationally stationary with respect to the borehole and rotating the work string relative to the part and the borehole to open the second outlet; and passing the cleaning fluid down the work string to the inlet of the apparatus and thence via the second outlet to the interior of the borehole above or adjacent the top of the liner.

13. A method as claimed in Claim 12 wherein the part and the obturating member comprises a sleeve.

The Patent Office

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Application No: GB 9808784.4
Claims searched: 1-13

Examiner: Brendan Churchill
Date of search: 28 September 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E1F FAW, FGL, FLJ, FLP

Int Cl (Ed.6): E21B

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2264137 A (Camco International Inc) Abstract and Figs 9 & 10	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.